(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 198 627**
B1

(12) # EUROPEAN PATENT SPECIFICATION

(45) Date of publication of patent specification: **07.02.90**

(51) Int. Cl.[5]: **B 22 F 3/26,** E 21 B 10/46, C 22 C 9/00, B 22 F 7/06

(21) Application number: **86302376.8**

(22) Date of filing: **01.04.86**

(54) **Improvements in or relating to the manufacture of rotary drill bits.**

(30) Priority: **02.04.85 GB 8508621**

(43) Date of publication of application:
22.10.86 Bulletin 86/43

(45) Publication of the grant of the patent:
07.02.90 Bulletin 90/06

(84) Designated Contracting States:
BE CH DE FR GB LI NL SE

(56) References cited:
GB-A- 353 663
GB-A- 652 086
US-A-3 453 719
US-A-4 078 713

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EP 0 198 627 B1

Courier Press, Leamington Spa, England.

Description

The invention relates to rotary drill bits for use in drilling or coring deep holes in subsurface formations.

In particular, the invention is applicable to rotary drill bits of the kind comprising a bit body having an external surface on which are mounted a plurality of cutting elements for cutting or abrading the formation, and an inner passage for supplying drilling fluid to one or more nozzles at the external surface of the bit. The nozzles are so located at the surface of the bit body that drilling fluid emerging from the nozzles flows past the cutting elements, during drilling, so as to cool and/or clean them.

In drill bits of this type the cutting elements may be in the form of so-called "preform" cutting elements in the shape of a tablet, often circular, having a superhard cutting face formed of polycrystalline diamond or other superhard material.

One commonly used method of making rotary drill bits of the above mentioned type comprises forming a hollow mould for moulding at least a portion of the bit body, locating a plurality of cutting elements on the internal surface of the hollow mould, packing at least part of the mould with powdered matrix material, locating a body of infiltrant alloy above the powdered matrix material, and heating the filled mould in a furnace so that the alloy fuses and infiltrates downwardly through the powdered material to form a matrix.

Using conventional infiltration alloys, the furnace temperature required to form the matrix is usually of the order of 1000°C to 1170°C and this leads to certain disadvantages. Conventional polycrystalline diamond preforms are only thermally stable up to a temperature of 700°-750°C. For this reason natural diamonds are normally the only type of cutting elements which can be located in the mould and secured to the matrix during the infiltration process. US-A-3453719 discloses a method of this kind, using natural diamonds. Preform cutting elements, or cutting structures incorporating such elements, have hitherto normally been mounted in the bit body after it has been infiltrated. The interior surface of the mould is therefore normally suitably shaped to provide surfaces to which the cutting elements may be subsequently brazed, or to provide sockets to receive studs or carriers to which the cutting elements are bonded. The subsequent mounting of the cutting elements on the body is a time-consuming and costly process, and may involve serious technical difficulties. The cutting elements and/or cutting structures must also be made sufficiently accurate to fit the pockets in the bit body, and this also adds to the cost.

There are now available certain polycrystalline diamond preforms which are thermally stable up to conventional infiltration temperatures, typically about 1100°C. However, the use of such thermally stable preforms gives rise to further problems, particularly with regard to ensuring that the cutting elements are securely mounted on the bit body with sufficient exposure for optimum cutting action.

Conventionally, before the matrix is formed, the mould is partly filled with a steel blank, the matrix being formed around the blank. After the matrix forming process, a further steel piece is welded onto a projecting portion of the blank and is shaped and formed with a thread to provide the threaded shank by means of which the drill bit may be connected to the drill string. The provision of the threaded shank must be effected after the matrix has been formed since the high infiltration temperature can cause metallurgical deterioration of the steel blank.

In order to avoid the above mentioned disadvantages, it has been proposed to use a low temperature infiltration alloy such that the infiltration temperature is below about 700°C, i.e. is at a temperature where conventional preforms are thermally stable. One such low temperature alloy has comprised 45% silver, 15% copper, 16% zinc and 24% cadmium. However, the use of such alloy has not proved commercially acceptable, not least because of its high cost.

The use of a low temperature alloy to form a matrix with a powdered metal is generally known, for example as shown in GB-A-652086, GB-A-353663 and US-A-40788713. However, such known art has not previously been considered to be applicable to the basic bit-forming method to which the present invention relates, as referred to above, and is not concerned with the manufacture of drill bits for drilling or coring holes in subsurface formations, and of this basic type.

The present invention sets out to provide a method of making such a drill bit using a low temperature infiltrant which may overcome the disadvantages of the known methods referred to above.

According to the invention a bit-forming method of the basic type referred to above is characterised in that the infiltrant alloy is a copper based alloy containing phosphorus and is selected to provide an infiltration temperature which is not greater than 850°C, and in that each cutting element is a preform cutting element having a superhard cutting face formed of polycrystalline diamond or other superhard material.

The comparatively low infiltration temperature according to the invention has the advantage that conventional preforms of the kind first described above may withstand the furnace temperature and may thus be located in the mould and incorporated in the bit body during formation of the matrix. Furthermore, the steel blank which is first introduced into the mould may be a one-piece element which may also be pre-machined to provide the threaded shank on the finished drill bit. Both these advantages may reduce significantly the cost of manufacture of the bit.

Although, as previously mentioned, thermally stable preforms may, in any case, be positioned in the mould at normal infiltration temperatures (1100°C-1170°C), the method of the present invention may also be used advantageously with such thermally stable preforms. This is because, at the lower infiltration temperature according to the present invention, the difference in coefficient of thermal expansion between the preforms and the matrix material has less deleterious effect than it does at higher temperatures. Thus, using the lower temperature method of the invention, the preform cutting elements may be more securely embedded in the matrix material owing to less stress occurring at the interface between the materials during cooling of the bit body from the infiltration temperature.

In the method according to the invention the alloy may be an essentially two-element copper-phosphorus alloy. The alloy may be of eutectic, or near-eutectic composition. For example, the alloy may comprise approximately 8.4% phosphorus in a copper base.

In a further alternative the infiltration alloy may be a copper-phosphorus-tin alloy. For example, the alloy may comprise approximately 85% copper, up to 10% tin and up to 10% phosphorus.

Another form of low temperature infiltration alloy which may be used in the invention is a copper-phosphorus-silver alloy having a copper base, up to 8% of phosphorus and up to 20% of silver. However, the proportion of silver in the alloy is preferably something of the order of 2% in view of the high cost of silver.

The single figure is a diagrammatic vertical section through a mould showing the manufacture of a drill bit by the method according to the invention.

Referring to the drawing, a two-part mould 10 is formed from graphite or other suitable material and has an internal configuration corresponding generally to the required surface shape of the bit body or a portion thereof. For example, the mould may be formed with elongate recesses to provide radially extending blades upstanding from the surface of the finished bit. In the case where cutting elements are to be incorporated in the bit body during formation thereof, the internal surface of the mould may also be shaped to provide locations to receive the cutting elements, or cutting structures incorporating such cutting elements. The cutting elements or structures may, for example, be glued in position on the internal surface of the mould.

Alternatively, in the case where the cutting elements or cutting structures are to be mounted on the bit body after formation thereof, the surface of the mould may be formed with a plurality of sockets each of which receives a former, which formers, during formation of the matrix, define in the matrix sockets to receive the cutting elements or structures, such as studs, on which the cutting elements are mounted.

The matrix material is moulded on and within a hollow steel blank 11. The steel blank is supported in the mould 10 so that its outer surface is spaced from the inner surface of the mould. The blank has an upper cylindrical internal cavity 12 communicating with a lower diverging cavity 13. The upper portion of the blank 11 is formed with a machined external screw thread 14 which will form the threaded shank for connecting the drill bit to the drill string.

There is also provided in the mould 10, at each desired location for a nozzle in the finished bit, a socket 15 which receives one end of an elongate stepped cylindrical nozzle former 16 which extends into the mould space within the lower cavity 13 in the hollow steel blank 11.

After the insertion of the steel blank 11 into the mould, powdered matrix forming material (for example, powdered tungsten carbide) is packed around the outside of the steel blank and within the lower diverging cavity 13 of the blank, and around the formers 16 and the formers or cutting elements mounted over the internal surface of the mould. Tungsten metal powder is then packed in part of the upper cavity 12 in the steel blank 11.

A body of infiltrant alloy is then located, as indicated at 17, above the matrix forming material both within and around the steel blank 11. In accordance with the invention, the alloy is a copper-based alloy containing phosphorus and is selected to provide an infiltration temperature which is not greater than 850° C and is preferably not greater than 750° C.

A suitable alloy is a two-element copper-phosphorus alloy which is of eutectic or near-eutectic composition. For example the alloy may comprise approximately 8.4% phosphorus in a copper base.

Another suitable form of alloy is a copper-phosphorus-tin alloy, for example comprising approximately 85% copper, up to 10% tin and up to 10% phosphorus.

Another form of low temperature infiltration alloy which is suitable is a copper-phosphorus-silver alloy having a copper base, up to 8% of phosphorus and up to 20% of silver. Preferably however the proportion of silver is of the order of 2% to reduce cost.

After the matrix forming material and infiltrant have been packed into the mould, the filled mould is placed in a furnace and heated to cause the alloy to fuse and infiltrate the matrix forming material in known manner. It has been found preferable to carry out the infiltration in the furnace in an atmosphere of dry hydrogen, for example hydrogen having a dew point of approximately -30°C. Alternatively, the infiltration may be carried out in a vacuum furnace.

In accordance with the invention, the alloy fuses and infiltrates the matrix powder at a temperature not greater than 850° C, which is considerably less than the infiltration temperature using the infiltration alloys employed hitherto.

After removal of the bit body from the mould, the formers 16 are removed from the body and the sockets so formed are then ready to receive nozzle assemblies. Similarly, if formers for the cutting structures are used, such formers are also removed from the bit body and the cutting structures fitted in the normal manner. However, as previously mentioned, an important advantage of the present invention is that it may allow the cutting elements or cutting structures to be embodied in the bit body during formation of the bit body in the mould since the comparatively low temperature of infiltration removes the risk of thermal damage to the cutting elements and cutting structures and there is also less risk of damage due to thermal stresses as the bit body cools after formation.

Furthermore, in view of the lower temperature of infiltration, there is also less risk of thermal deformation and damage to the steel blank. Consequently, the threaded portion of the steel blank may be suitable for use as the threaded shank of the finished drill bit without further machining, or with only minimum machining.

In known matrix forming methods where the matrix has been formed around a steel blank, the coefficient of thermal expansion of the matrix is normally matched as closely as possible to the coefficient of thermal expansion of the steel blank so as to prevent spalling or cracking due to thermal stress. This may mean that the other characteristics, such as the hardness characteristics, of the matrix material have to be compromised. According to the present invention however, since the infiltration temperature is lower, the thermal stress is less so that the coefficient of thermal expansion of the matrix does not need to be matched so closely to the coefficient of thermal expansion of the steel blank. There is therefore more scope for selecting the matrix material according to the other desirable characteristics of the solidified matrix.

Claims

1. A method of making a rotary drill bit for drilling or coring holes in subsurface formations, comprising forming a hollow mould for moulding at least a portion of the bit body, locating a plurality of cutting elements on the internal surface of the hollow mould, packing at least part of the mould with powdered matrix material, locating a body of infiltrant alloy above the powdered matrix material, and heating the filled mould in a furnace so that the alloy fuses and infiltrates downwardly through the powdered material to form a matrix, wherein the infiltrant alloy is a copper based alloy containing phosphorus and is selected to provide an infiltration temperature which is not greater than 850°C, and in that each cutting element is a preform cutting element having a superhard cutting face formed of polycrystalline diamond or other superhard material.

2. A method according to Claim 1, wherein the alloy is selected to provide an infiltration temperature which is not greater than 750°C.

3. A method according to Claim 1, wherein the alloy is an essentially two-element copper-phosphorus alloy.

4. A method according to Claim 3, wherein the alloy is substantially of eutectic composition.

5. A method according to Claim 4, wherein the alloy comprises approximately 8.4% phosphorus in a copper base.

6. A method according to Claim 1, wherein the alloy is a copper-phosphorus-tin alloy.

7. A method according to Claim 6, wherein the alloy comprises approximately 85% copper, up to 10% tin and up to 10% phosphorus.

8. A method according to Claim 1, wherein the alloy is a copper-phosphorus-silver alloy.

9. A method according to Claim 8, wherein the alloy includes up to 8% phosphorus and up to 20% silver.

10. A method according to Claim 9, wherein the alloy includes approximately 2% silver.

11. A method according to Claim 1, wherein the infiltration in the furnace is effected in a hydrogen atmosphere.

12. A method according to Claim 11, wherein the hydrogen atmosphere has a dew point not greater than -30°C.

13. A method according to Claim 1, wherein the infiltration in the furnace is effected in a vacuum.

14. A method according to Claim 1, including the step of locating a steel blank within the hollow mould, before packing the mould around part of the steel blank with powdered matrix material, the steel blank being preformed with a threaded shank which constitutes the threaded shank of the finished drill bit.

Patentansprüche

1. Verfahren zum Herstellen eines Drehbohrmeißels zum Bohren oder Kernbohren von Löchern in unterirdischen Formationen durch Herstellen einer hohlen Form zum Formen von wenigstens einem Teil des Meißelkörpers, Anordnen von mehreren Schneidelementen auf der Innenoberfläche der hohlen Form, Füllen wenigstens eines Teils der Form mit pulverförmigem Matrixmaterial, Anordnen eines Tränklegierungsmaterials über dem pulverförmigen Matrixmaterial und Erhitzen der gefüllten Form in einem Ofen, so daß die Legierung schmilzt und durch das pulverförmige Material nach unten sickert, um eine Matrix zu bilden, wobei die Tränklegierung eine Kupferbasislegierung ist, die Phosphor enthält und so gewählt wird, daß sich eine Tränktemperatur ergibt, die nicht größer als 850°C ist, und wobei jedes Schneidelement ein vorgeformtes Schneidelement ist, das eine superharte Schneidfläche hat, die aus polykristallinem Diamantoder anderem superharten Material gebildet ist.

2. Verfahren nach Anspruch 1, wobei die Legierung so gewählt wird, daß sich eine Tränktemperatur ergibt, die nicht größer als 750°C ist.

3. Verfahren nach Anspruch 1, wobei die Legierung im wesentlichen eine Zweistoff-Kupfer-Phosphor-Legierung ist.

4. Verfahren nach Anspruch 3, wobei die Legierung im wesentlichen eine eutektische Zusammensetzung hat.

5. Verfahren nach Anspruch 4, wobei die

Legierung ungefähr 8,4% Phosphor in einer Kupferbasis enthält.

6. Verfahren nach Anspruch 1, wobei die Legierung eine Kupfer-Phosphor-Zinn-Legierung ist.

7. Verfahren nach Anspruch 6, wobei die Legierung ungefähr 85% Kupfer, bis zu 10% Zinn und bis zu 10% Phosphor enthält.

8. Verfahren nach Anspruch 1, wobei die Legierung eine Kupfer-Phosphor-Silber-Legierung ist.

9. Verfahren nach Anspruch 8, wobei die Legierung bis zu 8% Phosphor und bis zu 20% Silber enthält.

10. Verfahren nach Anspruch 9, wobei die Legierung ungefähr 2% Silber enthält.

11. Verfahren nach Anspruch 1, wobei das Tränken in dem Ofen in einer Wasserstoffatmosphäre ausgeführt wird.

12. Verfahren nach Anspruch 11, wobei die Wasserstoffatmosphäre einen Taupunkt hat, der nicht größer als -30°C ist.

13. Verfahren nach Anspruch 1, wobei das Tränken in dem Ofen in einem Vakuum ausgeführt wird.

14. Verfahren nach Anspruch 1, beinhaltend den Schritt, einen Stahlrohling in der hohlen Form anzuordnen, bevor die Form um einen Teil des Stahlrohlings mit pulverförmigem Matrixmaterial gefüllt wird, wobei der Stahlrohling mit einem Gewindeschaft vorgeformt wird, der den Gewindeschaft des fertigen Bohrmeißels bildet.

Revendications

1. Procédé de fabrication d'un trépan de forage rotatif pour le forage ou l'alésage de trous dans des formations souterraines, dans lequel on forme un moule creux pour mouler au moins une portion du corps du trépan, on place une pluralité d'éléments de coupe sur la surface interne du moule creux, on remplit au moins une partie du moule avec un matériau de matrice pulvérulent, on place une masse d'alliage d'infiltration audessus du matériau de matrice pulvérulent et on chauffe le moule rempli dans un four de telle façon que l'alliage fonde et s'infiltre vers le bas à travers le matériau pulvérulent afin de former une matrice, caractérisé en ce que l'alliage d'infiltration est un alliage à base de cuivre contenant du phosphore et il est choisi de manière à avoir une température d'infiltration qui n'est pas supérieure à 850°C, et en ce que chaque élément de coupe est un élément de coupe préformé ayant une face de coupe très dure formée en diamant polycristallin ou en un autre matériau très dur.

2. Procédé suivant la revendication 1 caractérisé en ce que l'alliage est choisi de manière à avoir une température d'infiltration qui n'est pas supérieure à 750°C.

3. Procédé suivant la revendication 1 caractérisé en ce que l'alliage est un alliage comprenant essentiellement deux éléments à savoir du cuivre et du phosphore.

4. Procédé suivant la revendication 3 caractérisé en ce que l'alliage a pratiquement une composition eutectique.

5. Procédé suivant la revendication 4 caractérisé en ce que l'alliage comprend approximativement 8,4% de phosphore dans une base en cuivre.

6. Procédé suivant la revendication 1 caractérisé en ce que l'alliage est du type cuivre-phosphore-étain.

7. Procédé suivant la revendication 6 caractérisé en ce que l'alliage comprend approximativement 85% de cuivre, jusqu'à 10% d'étain et jusqu'à 10% de phosphore.

8. Procédé suivant la revendication 1 caractérisé en ce que l'alliage est du type cuivre-phosphore-argent.

9. Procédé suivant la revendication 8 caractérisé en ce que l'alliage comporte jusqu'à 8% de phosphore et jusqu'à 20% d'argent.

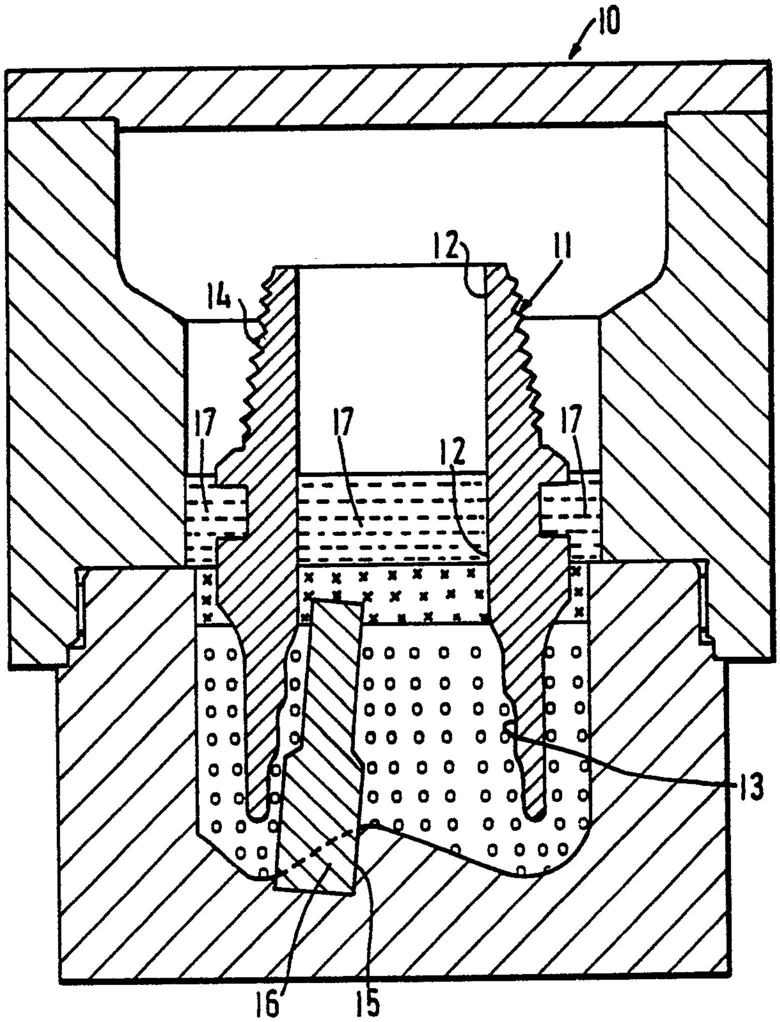
10. Procédé suivant la revendication 9 caractérisé en ce que l'alliage comporte approximativement 2% d'argent.

11. Procédé suivant la revendication 1 caractérisé en ce que l'infiltration dans le four est effectuée dans une atmosphère d'hydrogène.

12. Procédé suivant la revendication 11 caractérisé en ce que l'atmosphère d'hydrogène a un point de rosée qui n'est pas supérieur à moins -30°C.

13. Procédé suivant la revendication 1 caractérisé en ce que l'infiltration dans le four est effectuée sous vide.

14. Procédé suivant la revendication 1 caractérisé en ce qu'il comprend l'étape consistant à mettre en place un noyau en acier dans le moule creux, avant de remplir le moule, autour d'une partie du noyau en acier, avec le matériau de matrice pulvérulent, le noyau en acier étant préformé avec un fût fileté qui constitu le fût fileté du trépan de forage fini.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